

LOW SOLAR ABSORBING CHEMICAL AGENT RESISTANT COATINGS WITH NANO-ADDITIVES

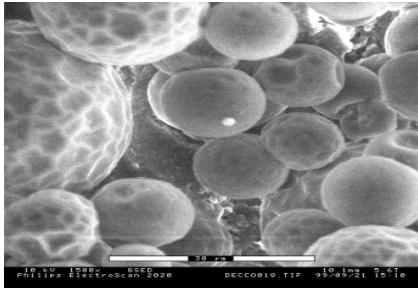
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Outline



Courtesy of U.S. Army

- OVERVIEW
- DETAILS OF CHALLENGES
- FORMULATION ELEMENTS
- STATUS

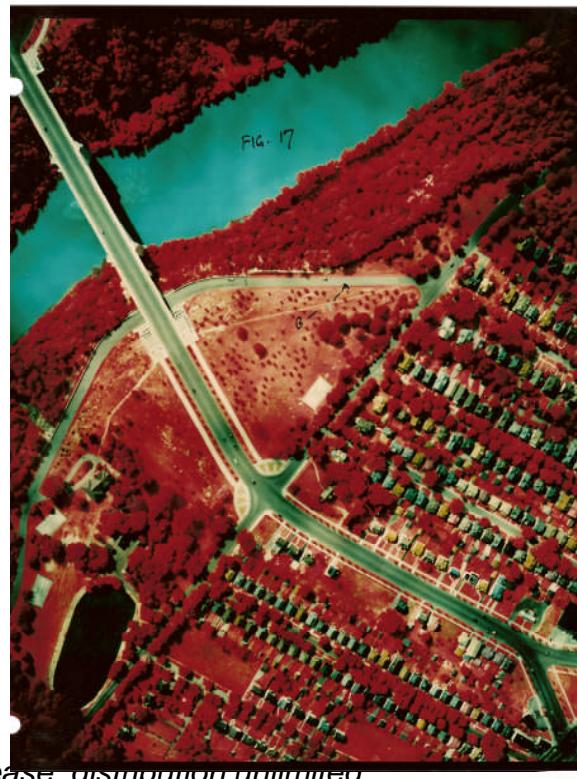
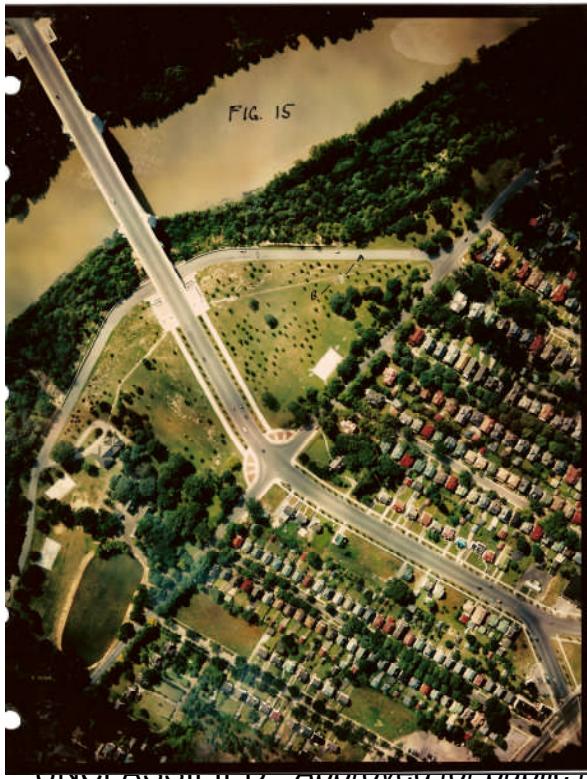


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Objective:

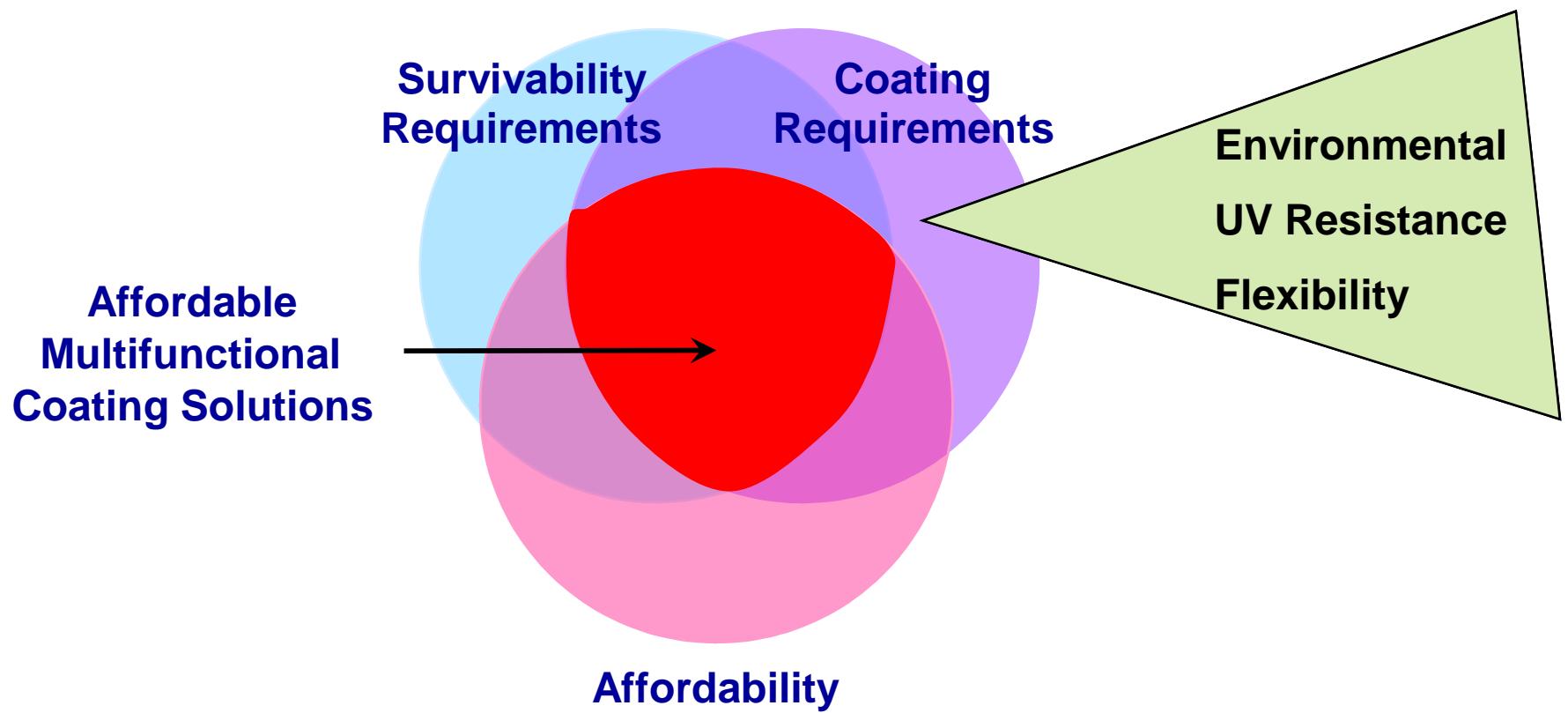
Provide advance coatings technology that will increase the functionality and durability of Army materiel



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Increased Options for Balanced Requirements



*New coatings formulations
More Survivable and Durable Platforms*

Today

CARC Camouflage Polyurethane Topcoat (1.8 mil)

- Visible and NIR
- Silica extender
- Semitransparent binders

CARC epoxy primer (0.8 - 1.2 mils)

Chemical Conversion Coating (0.2-0.3 mil)

Substrate (ferrous or nonferrous)

Tomorrow

Tailored CARC Coating

- Functional pigmentation
- Controlled Roughness

Functional Primer

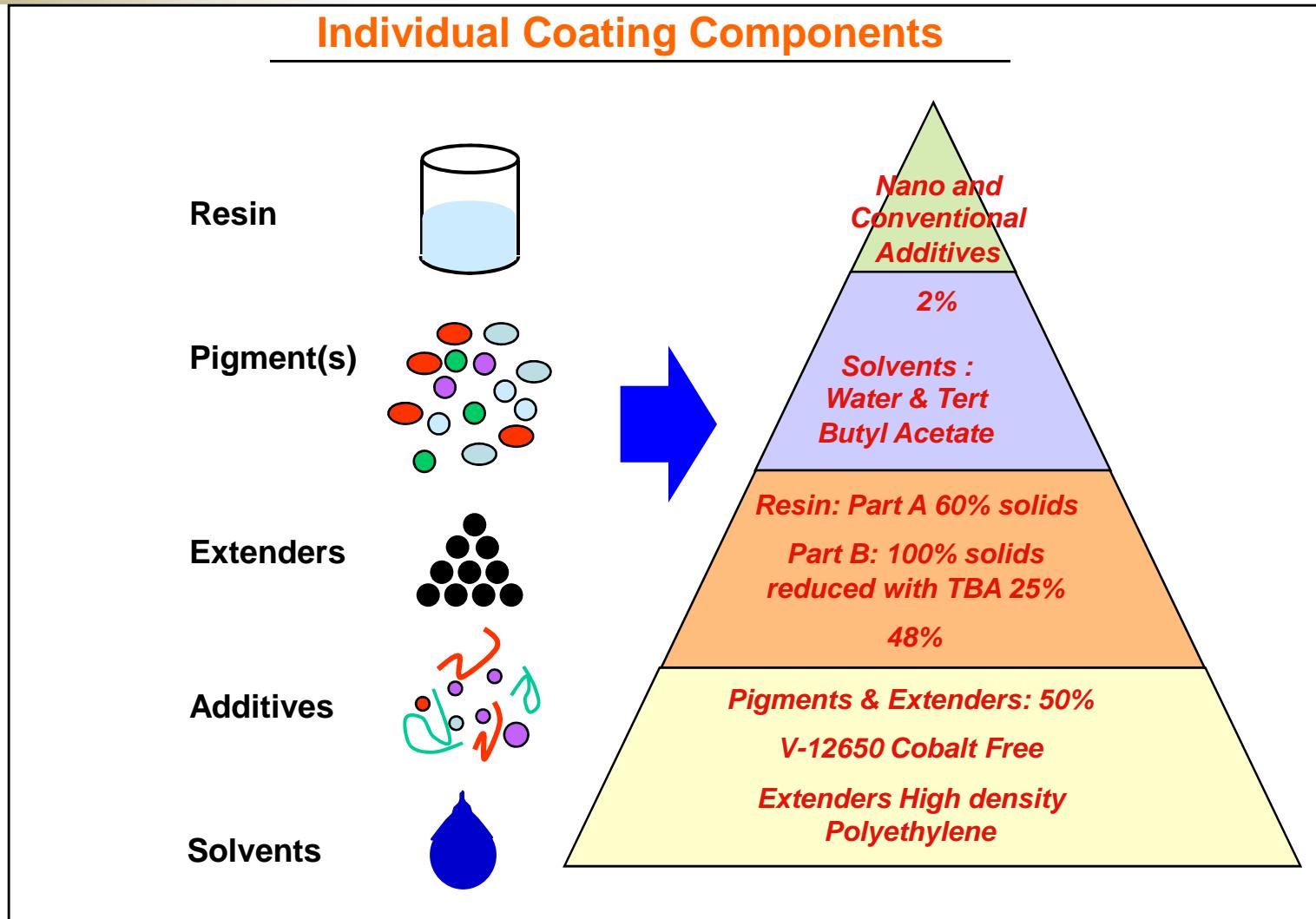
- Corrosion Protection
- Texture

Advanced Corrosion Protection Layer

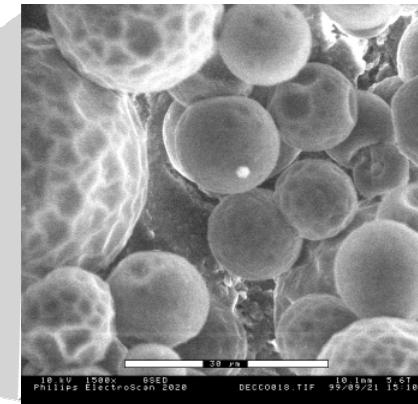
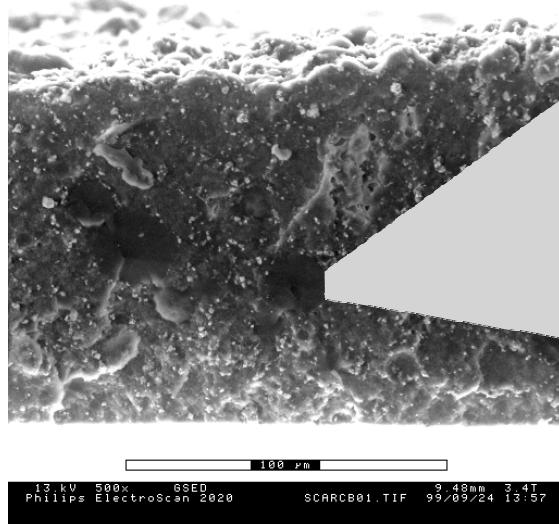
Substrate

- Ferrous
- Nonferrous
- Polymer Composite

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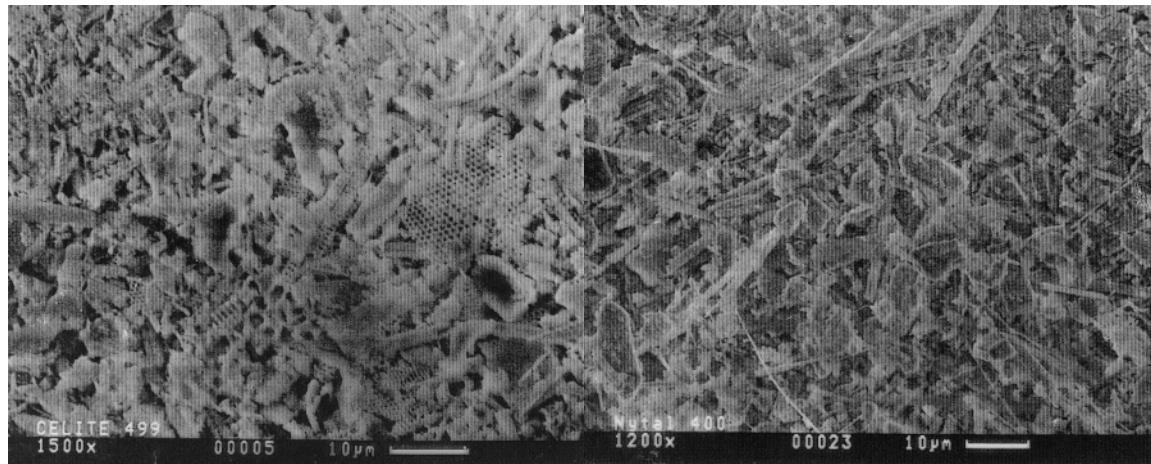


Polymeric beads



- Integrated within Film

- **Polymeric beads**
 - Reduce chalking effect
 - Improve UV resistance
 - Improve performance



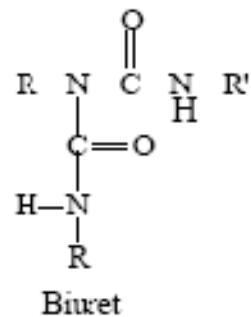
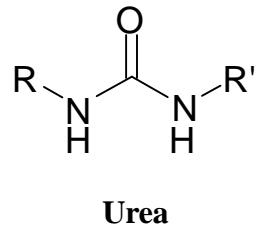
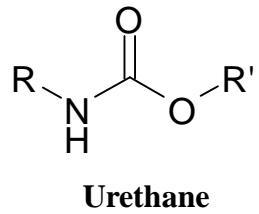
Diatomaceous silica

Talc

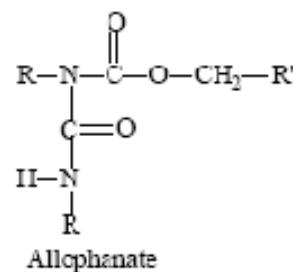
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- Unacceptable CAR at NCO:OH < 4
- NMR and FTIR to measure quantify ratio of side products vs. NCO:OH ratio
- Adjust additives, reaction conditions, etc.
 - to make more favorable distribution



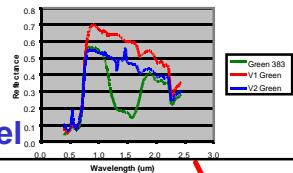
(Urea +
isocyanate)



(Urethane
+
isocyanate)

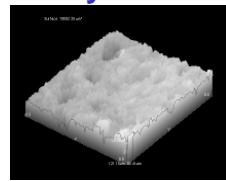
Reflectance

- Specular (gloss)
- Spectral (color)
- Global Exposure Model



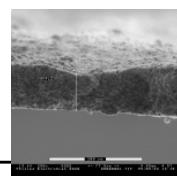
Microscopy

- Physical Changes At Surface
- Failure Analysis



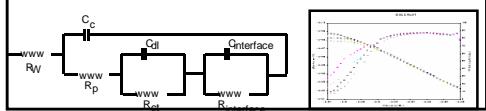
SEM Coating X-section

- Fracture Surface of System
- Constituent Adhesion



Electrochemical Impedance Spectroscopy (EIS)

- Equivalent Circuit Modeling of corrosion behavior



Topcoat

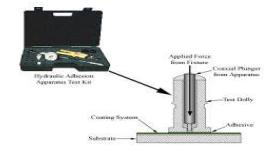
Epoxy Primer

Pretreatment

Substrate

Accelerated Weathering

- Durability, thermal/irradiated
- Degradation, moisture sensitivity

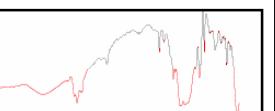


Adhesion Testing

- Durability, flexibility, strength

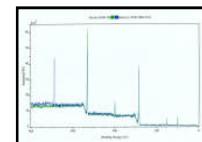
Chemical Structure and Transport Properties

- FTIR/ATR,
- Raman, DGC-MS



SEM-EDX, SAM, XPS, UV-VIS

- Chromium concentrations
- Oxidation states



Accelerated Corrosion Testing

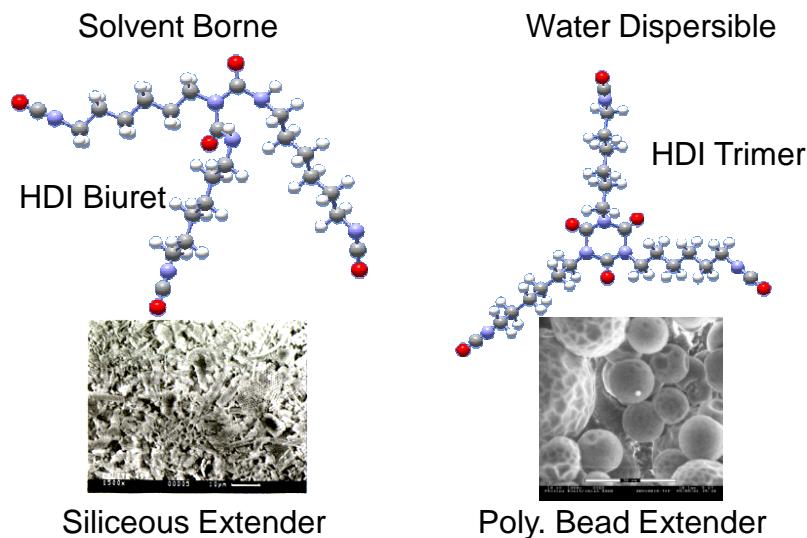
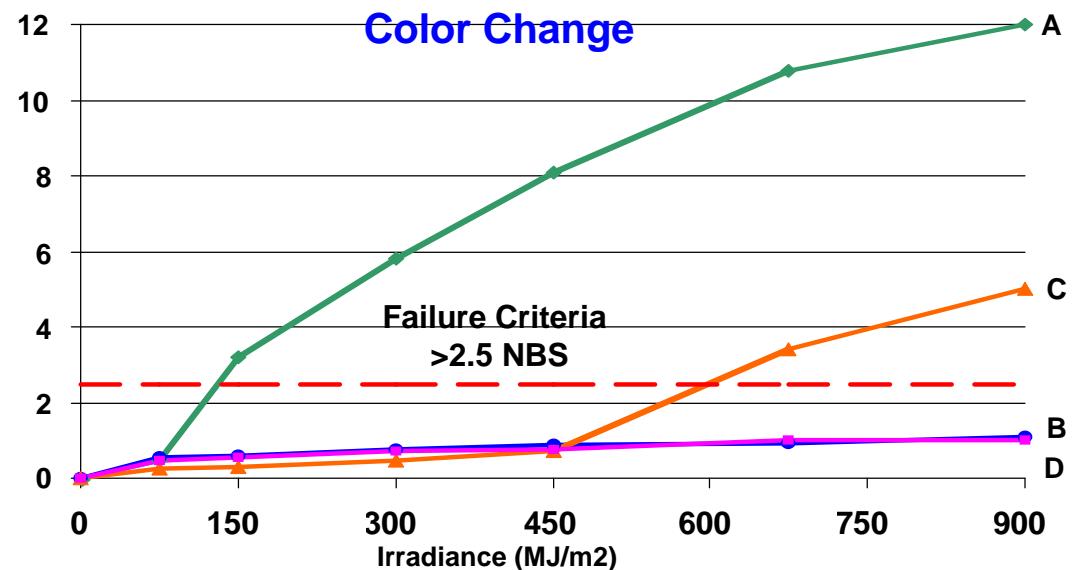
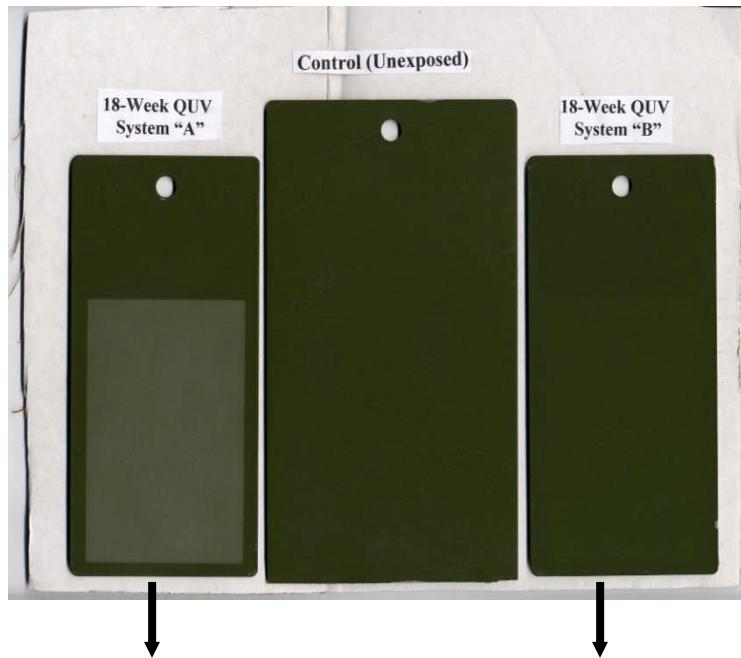
- Permeability, corrosion resistance

DMA, DSC

- T_g , stiffness, crosslink density, extent of cure

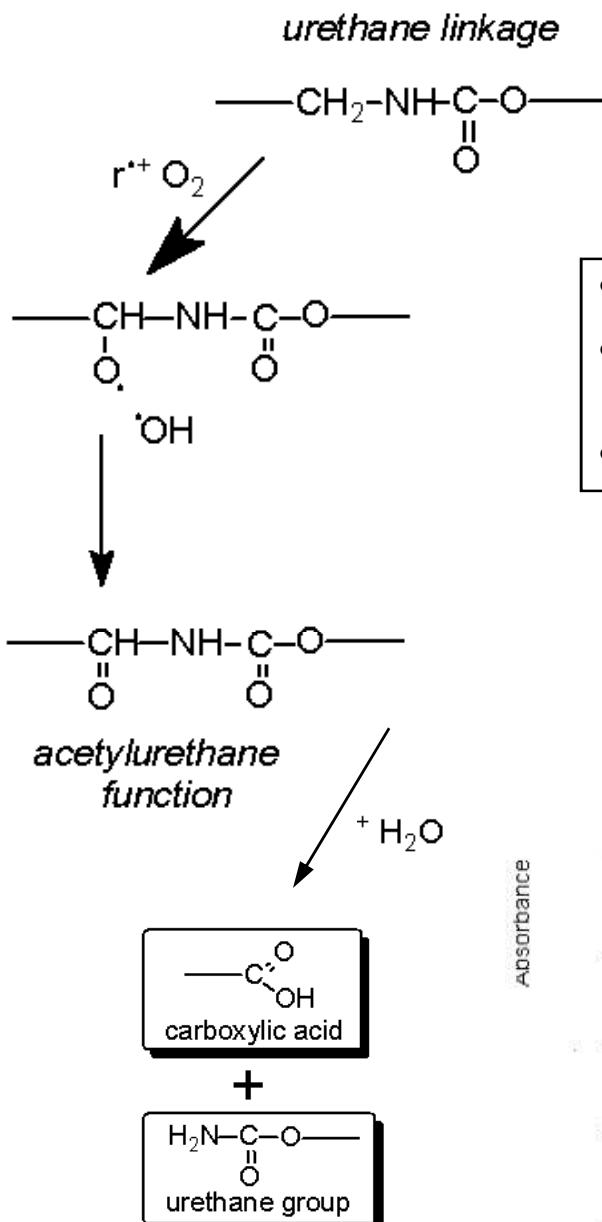
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Accelerated UV Degradation

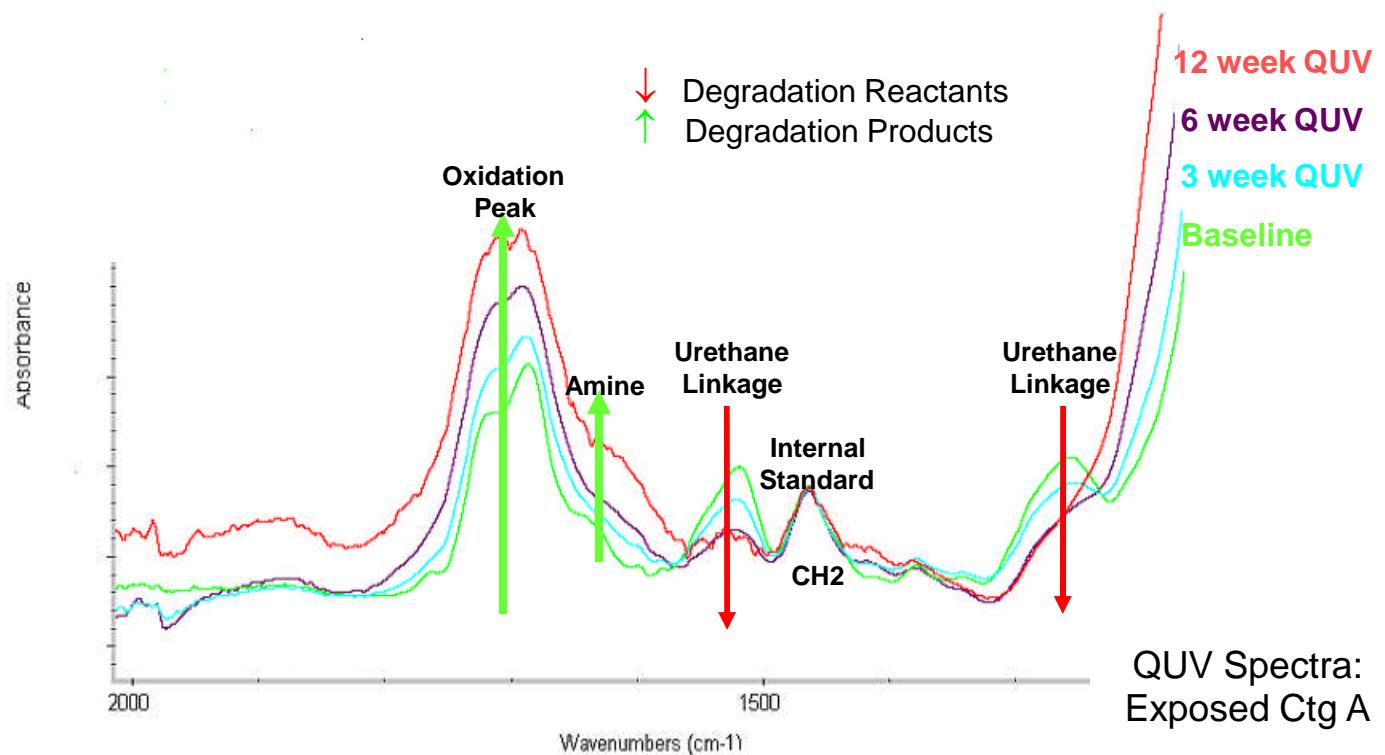


Top Coat	Resin Part A	Resin Part B	Extenders
A Army Green	Saturated Polyester Resin (functional -OH)	HDI Biuret (NCO) 75% resin solids, 25% solvent	Siliceous
B Army Green	Hydroxyl Functional PU Water Dispersible	Modified HDI Trimer Waterborne	Polymeric Beads
C Nav/Air Grey	Saturated Polyester Resin	HDI Trimer 75% resin solids, 25% solvent	Siliceous w./fluoro additives
D Nav/Air Grey	Conventional Polyester: 100% solid (low MW)	Blend of HDI Trimers 100% solid	Siliceous w./fluoro additives

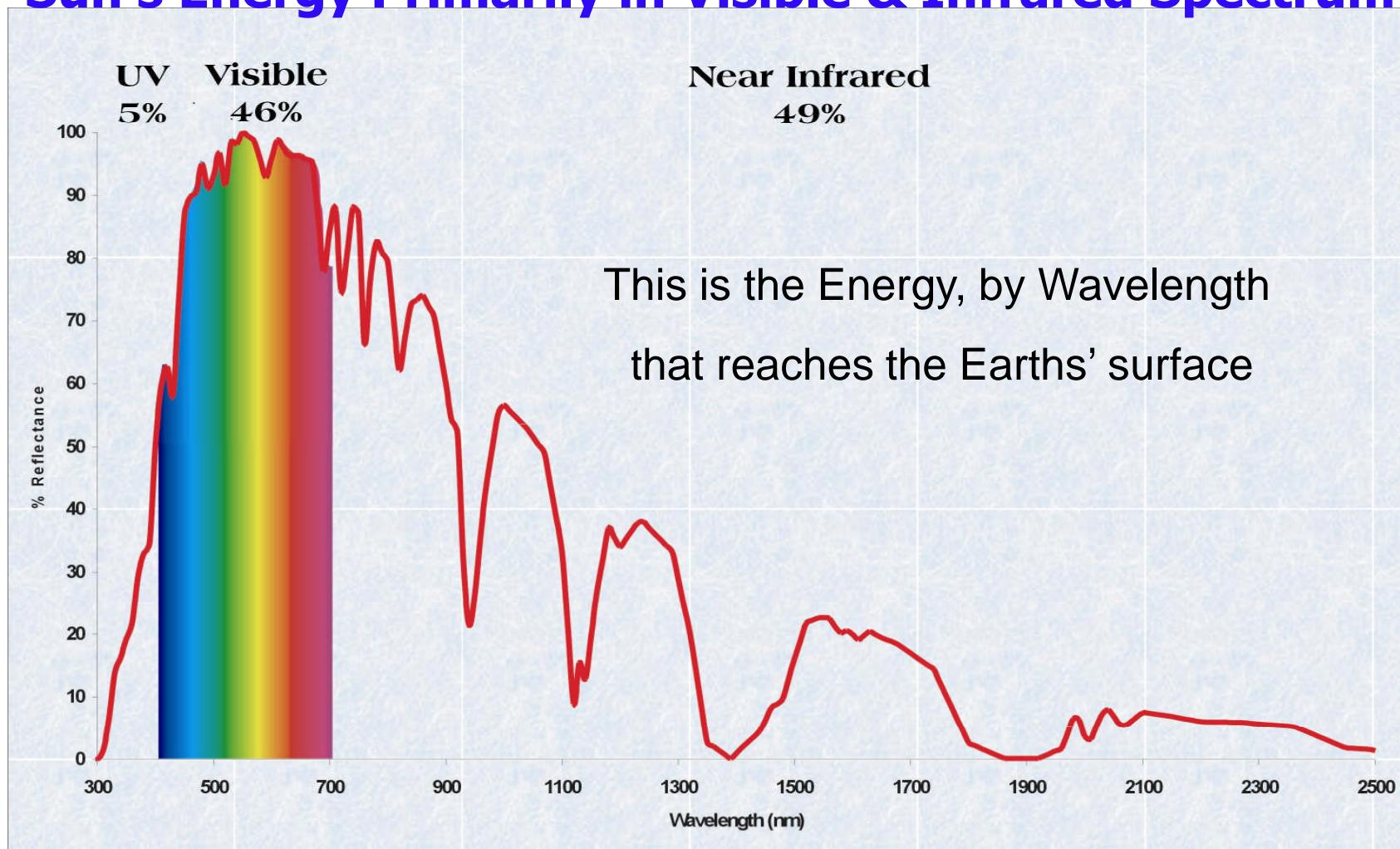
Photo Oxidation Mechanism Proposed & Verified



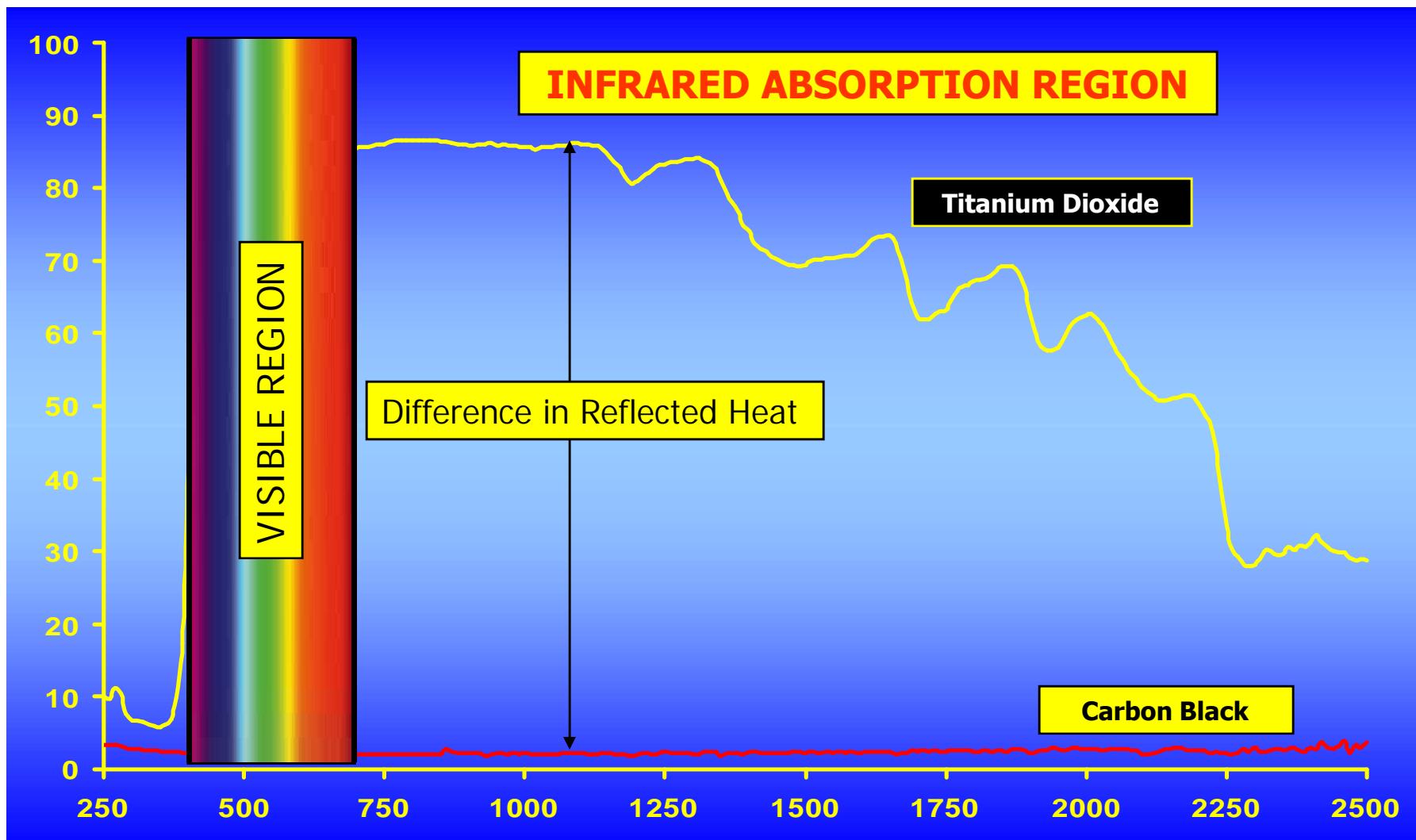
- Urethane linkages act as MCS binder
- Chain scission of urethane linkage in presence of UV irradiation & oxygen
- Degradation reactants & products are tracked by ATR-IR



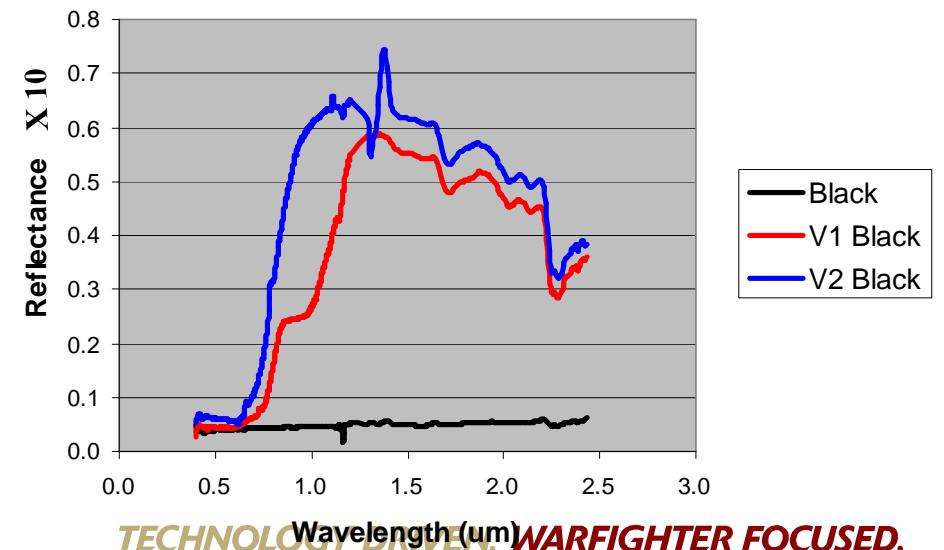
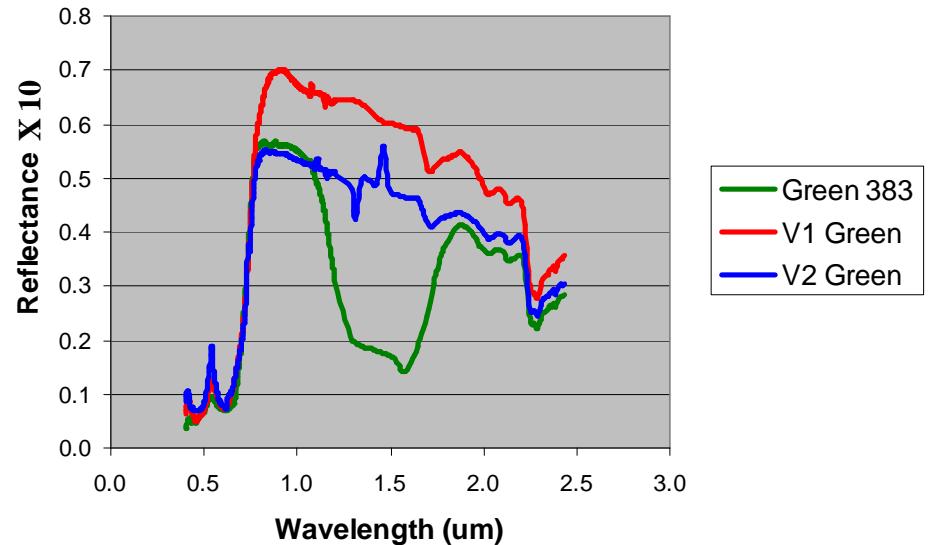
Sun's Energy Primarily in Visible & Infrared Spectrum

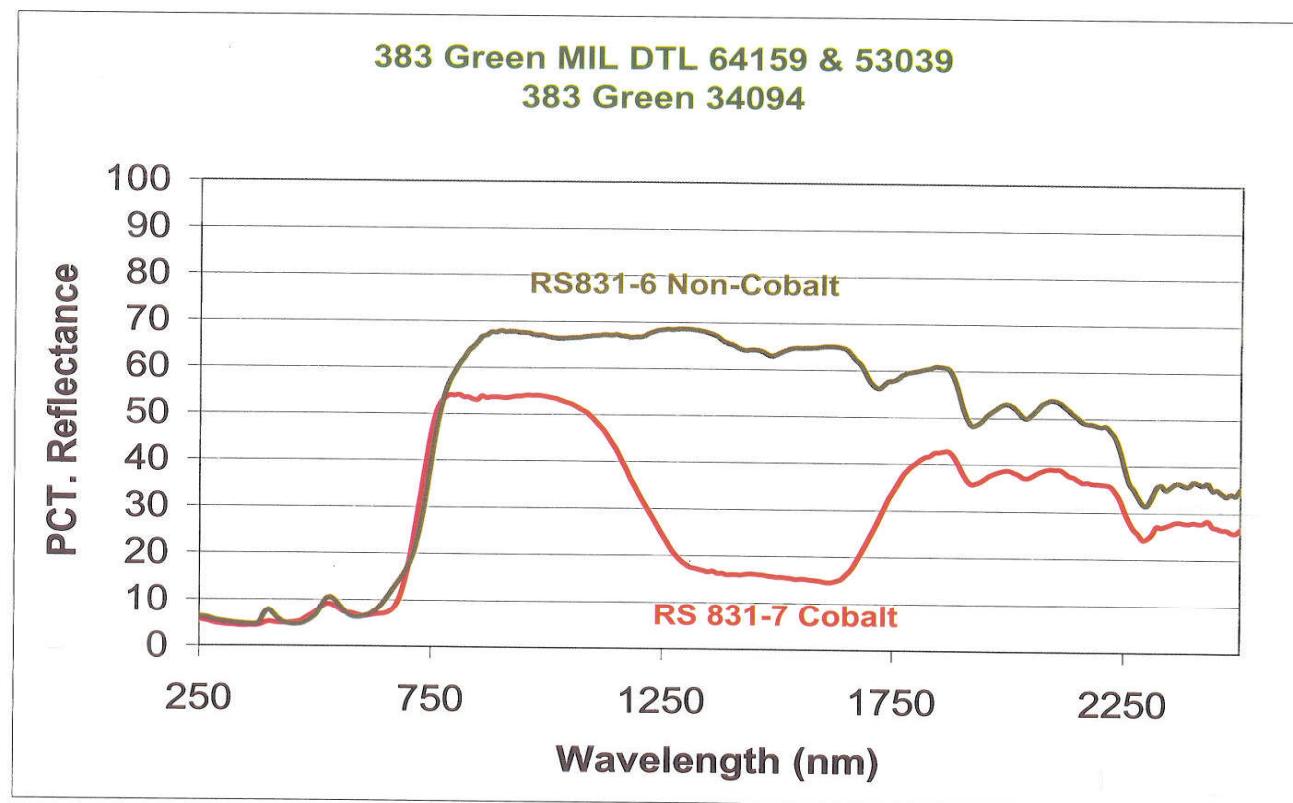


This is the Energy, by Wavelength
that reaches the Earths' surface



- ❖ Visually identical colors
- ❖ Higher Reflectance lower Temperature
- ❖ Reduce current coatings surface temperatures 20 to 50 Fahrenheit
- ❖ Major reductions in sustainability cost with extended coating life and with lower operating temperatures







Low Solar Absorbing CARC



- 2 year weathering excellent: Less than 1 color unit change
- Formulated four Primary Colors
- IR requirements will shift from 380nm -900nm to 380nm-2000nm with emphasis on 750nm to 1700nm.
- Visible unchanged
- Key highlight: COST, cobalt spinal increase of 300% and availability erratic
- Formulation will be cobalt free for 383 Green, AC Green, 383 Brown
- 383 Green to change to 808 Green to identify change
- Open to other approaches*



Low Solar Absorbing CARC



- ❖ 808 Green will be introduced as a new color this calendar year
- ❖ Specifics for IR and Color space will be provided to vendors and acceptance will be verified for all vendors prior to QPD issue



Acknowledgements



Co-Authors:

- Kes Chesonis, ARL
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 - Dan Pope
 - Wendy Kosik
 - Dawn Crawford

Corrosion Resistant Materials for Armor

Aluminum Alloy 5059 For Armor Applications Foreign Comparative Test Program

- Updated military Al armor specification MIL-DTL-46027K
- Over \$14M to date in acquisition
 - \$12M+ in direct procurement of AA5059 for RG-33 MRAP
 - Over \$1.1M of acquisition by OEMs for internal testing, design, and prototyping
 - AA5059-H131 chosen as primary (100%) common hull material for all 8 variants of the PM FCS-BCT Manned Ground Vehicle (MGV) by Boeing (LSI), General Dynamics, and BAE Systems



MRAP RG-33



(8) MGV Mission Based Variants



FUTURE COMBAT SYSTEMS
FCS
One Team-The Army/Defense/Industry

- Related work - military specification MIL-DTL-32262 created for 6061 Al

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